Recent Status of the TRISTAN Superconducting RF System

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Abstract

The TRISTAN superconducting RF system is the first large system applied to a storage ring and has been operated since 1988. Stability and reliability have become better with continual efforts of many people. This paper reports the recent status of our system.

1. INTRODUCTION

Performance of TRISTAN-MR is still improving. In the last autumn, before and after a machine study for the TRISTAN-II (B Factory) project, several tens of Q and SX - pole magnets were realigned. In the physics run after this machine study, the trip rate of SC-RF system was less than once per fill with 32 SC cavities and the same beam current as usual. Probably because of this realignment, the beam current has been much increased in the present running period. The operating condition after the last report [1] is added at the bottom of Table 1. The maximum beam current is 18.5 mA at the beginning of acceleration and 16.7 mA at the beginning of collision.

Hardware trouble happened once in March. The control system of our helium refrigerator tripped owing to instantaneous failure of electric power line. As a result, pressure in helium vessels rose and one of cavity pairs leaked at some indium joints. It took 5 days to replace the module with a dummy beam pipe and to make vacuum condition ready for beam operation.

Although the beam current was higher than before, the trip rate of SC-RF system was low for the first one month. However, it increased rapidly and eventually 6 cryostats were warmed up to about 50 K to degass adsorbed hydrogen. The effect of degassing is discussed in the last section.

2. HARDWARE PERFORMANCE

The HOM damping system is working well with a beam current of 4 x 4.5 mA. HOM power estimated from the measurement [2] is about 200 W per coupler, and the temperature of the ceramic connectors are mostly less than 20 ^{o}C, which are around -10 ^{o}C without beam. RF input couplers are running with power level of about 50 kW.

Figure 1 shows the distribution of the maximum accelerating gradient (Eacc,max) measured after the last report. In Fig. 1, a) and b) are those measured after the operation of 5 and 2 months respectively, and c) is a data before the present operation. When the operation becomes long, we usually find some degraded cavities, where the limitation is arcing caused by electron multipacting at the input coupling port. In other most cases, the limitation is thermal quench.

Table 1: Summary of the operation of SC Cavities in TRISTAN-MR

Period		Number of cav. (at 4K)	(operated)	Total Vc (MV)	Eacc(ave.) (MV/m)	Energy (GeV)	Current (mA)	Physics Run (days)
1988	Nov-Dec	16	16	105-109	4.4-4.6	30.0	10	18
1989	Jan-Mar	16	14	82-88	4.0-4.2	30.4	9	49
	May-Jun	14	14	87	4.2	30.4	10	17
	Jun-Jul	16	16	105	4.4	30.7	10	37
	Oct-Dec	30	28-29	190-200	4.6-4.7	32.0	12	25
1990	Feb-Mar	32	31	160	3.5	29.0	12	37
	Apr-May	32	30-31	160	3.5-3.6	29.0	12	25
	May-Jun	32	28-30	150-160	3.6	29.0	13	39
	July	30	25	130	3.5	29.0	13	31
1991	Jan-Jul	32	29-30	140-145	3.3	29.0	9	36
	Oct-Dec	30	26	140	3.6	29.0	13	35
1992	Feb-Mar	26	23	125	3.6	29.0	12	31
	Apr-Jun	28	23-25	135-140	3.8	29.0	13	77
	Oct-Dec	32	25-31	150-170	3.3-4.1	28.8-29.9	13	66
1993	Feb-Apr	30-32	28-32	145	3.2	29.0	13	48
	May-Jun	32	28-32	145	3.2	29.0	13	48
	Oct-Dec	32	32	145	3.0	29.0	13	25
1994	Feb-Mar	32	32	155	3.2	29.0	15	38
	Apr-May	30	27	155	3.8	29.0	15	57
	June	30	30	160	3.6	29.0	15	26
Total accumulated time of cavities		at 4.4 K :				29600 hours		

Figure 2 shows the result of the unloaded Q value measurement by liquid helium consumption. Static heat load is 20 ~25 W per cryostat. The old ones keep the initial performance for more than 5 years.

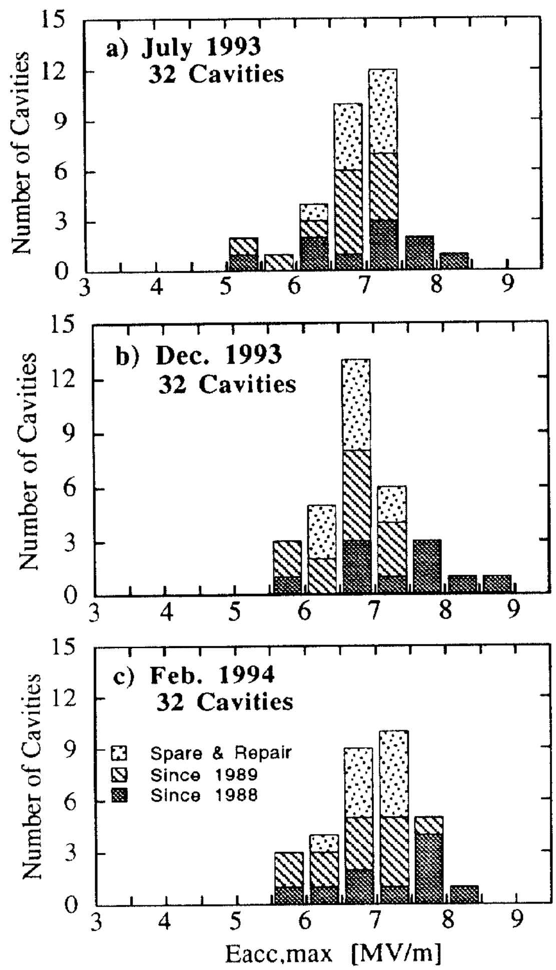

Fig. 1 Distribution of the maximum accelerating gradients.

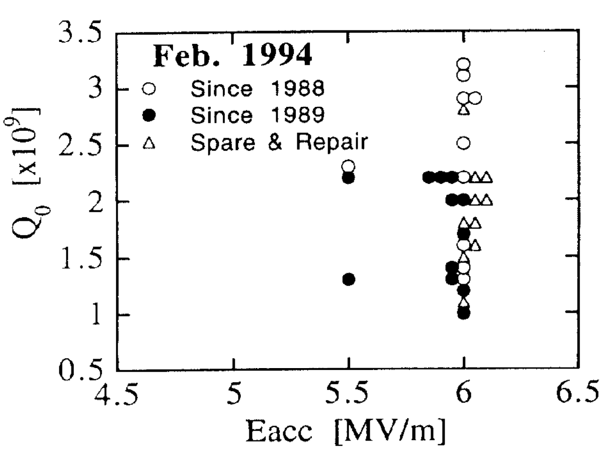

Fig. 2 Distribution of the unloaded Q values.

3. TRIP

Figure 3 shows the beam current and the total trip rate averaged by every ten fills in the present operation, and Figure 4 shows the distribution of the trips averaged in four periods. For the first one month, the total trip rate was less than one, where the main component was the fast breakdown of 10D#4 during acceleration. Three days after the operation with a dummy beam pipe (A in Fig. 3), the trip rate of both cavities (11C#4 and 11D#3) nearest to the dummy pipe increased suddenly, so the station 11D was detuned (B in Fig. 3). The total trip rate increased further and the rate of a beam missing fill became once per 10 fills on the average in May. As seen in Fig. 4, frequently tripping cavities were 10D#2, 10D#4, 11B#3, 11C#1 and 11C#4. So six cryostats containing these cavities and 11D#3 were warmed up to 50 K for about one day in June 6 (C in Fig. 3). The effect was very drastic in most cases, especially for 10D#2, 10D#4, 11B#3 and 11D#3. On the contrary, however, the effect was not clear for 11C#1 and 11C#4. The trip rate of 10D (o) and 11C (o) are also plotted in Fig. 3 as examples.

As is mentioned in the previous reports, we believe that the most of trips are discharge triggered by synchrotron radiation and the adsorbed gases play an important roll, though intermediate steps of the process is not clear. In some cases, we succeeded to reduce the trip rate by the adjustment of synchrotron radiation masks [3] and the realignment of Q magnets at a collision point [1].

The other way to reduce the trip rate is to cut the chain of the process by degassing the adsorbed gases in the cavity. Since the main component of the gases is hydrogen, warming up to about 50 K is considered to be enough. The amount of desorbed gases were 2.5 ~3 mTorr at 50 K for a volume of 500 liters, and about the same as usual. The result shows that this amount of adsorbed gases can enhance the trip rate very much and degassing is very effective. Also it becomes clear that there are cases where the adsorbed gases are not dominating. In the case of 11C#4, the trip increased after the installation of the dummy pipe, so ions, electrons or gases produced by synchrotron radiation at the dummy pipe might be contributing.

4. ACKNOWLEDGEMENT

The authors wish to thank SCC vacuum and refrigerator groups for the cooperation in the warming up study.

5. REFERENCES

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[3] K. Akai et al., "Operational Experience with the TRISTAN Superconducting RF System", *Proc. of the 1991 Part. Acc. Conf.*, San Fransisco, U.S.A., May 1991, pp. 2405-2407.

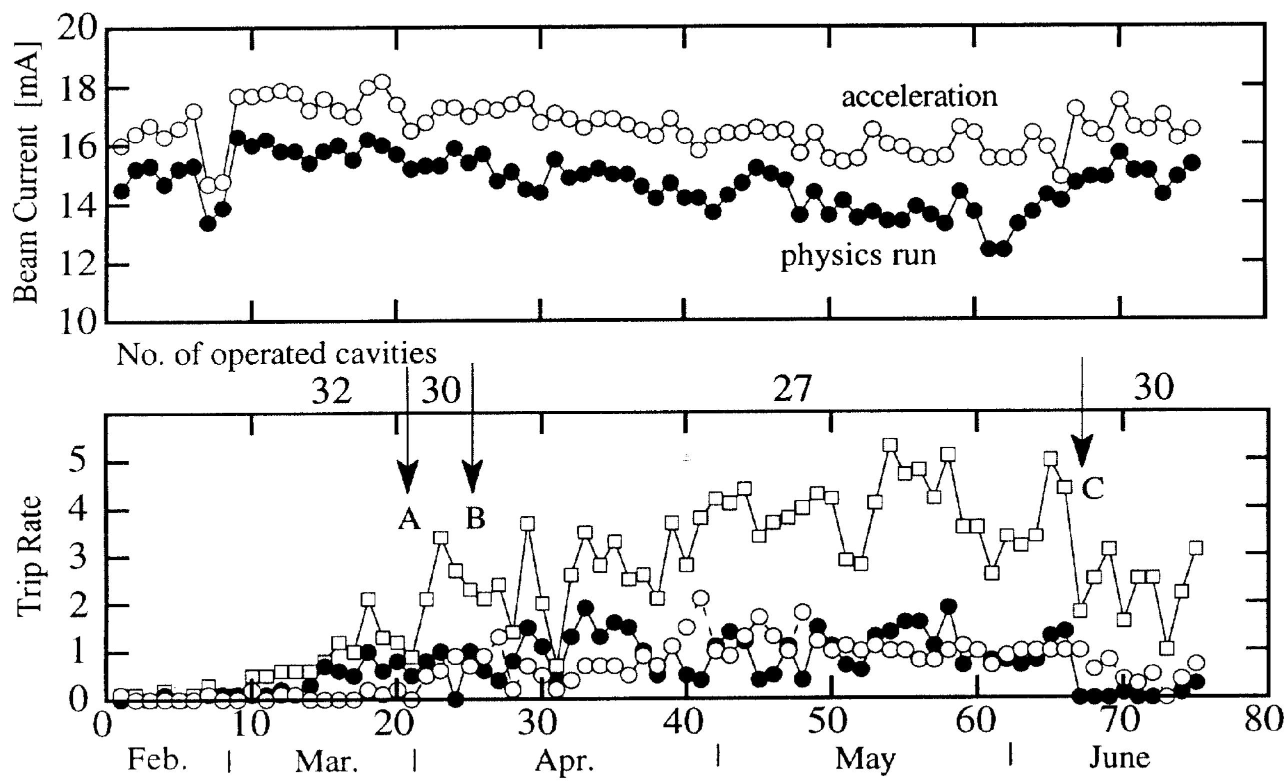

Fig. 3 The beam current and the trip rate averaged by every 10 fills.

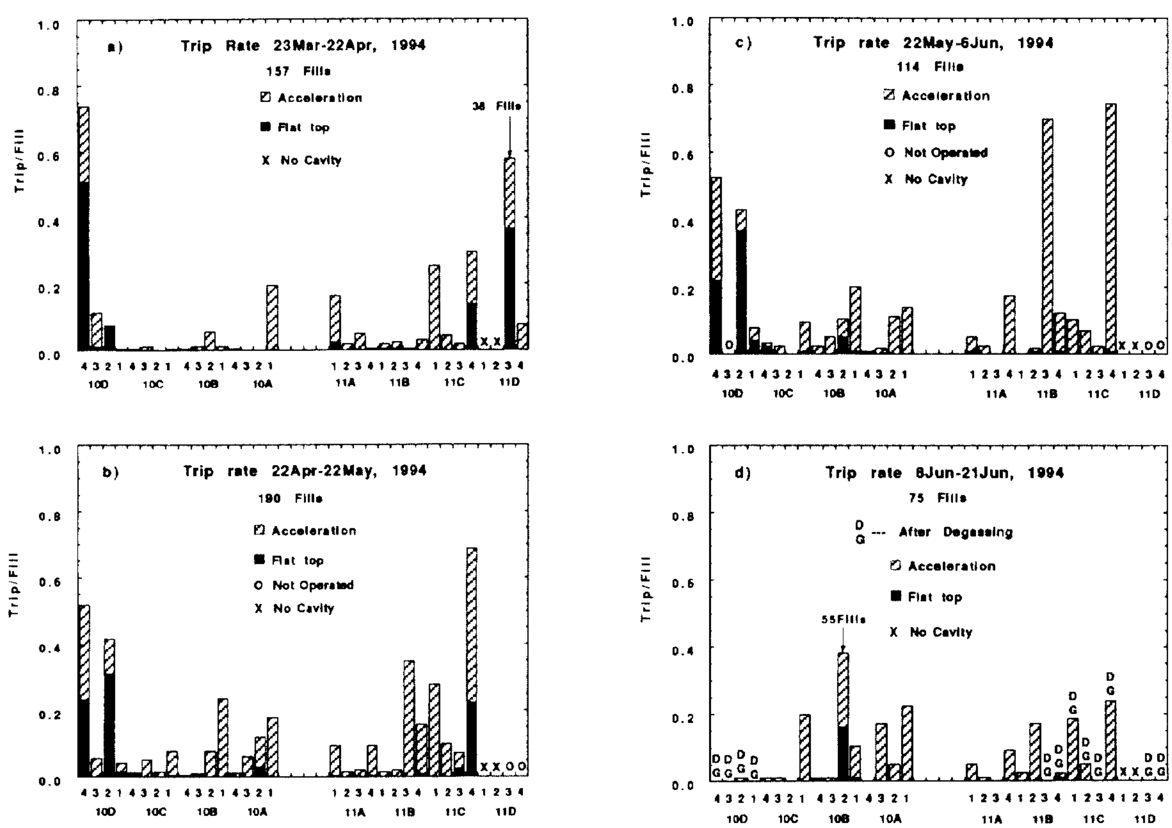

Fig. 4 Distribution of the trips.